MINIATURE IMAGING SPECTROMETER FOR LOW-COST PLANETARY MISSIONS

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Abstract

We present a design and test results for an instrument that extends the proven scientific capabilities of imaging spectrometry to a substantially wider range of missions by combining two technological breakthroughs to dramatically reduce the mass and size of imaging spectrometers, while maintaining performance. Imaging spectrometers have been among the most scientifically-productive instruments to be flown on aircraft and orbital spacecraft. However, the high mass of these instruments has put them out of the payload capacity of low-cost missions. Imaging spectrometers enable identification and compositional imaging of minerals, soils, ices, and organics; abilities beyond those of the panchromatic and multispectral cameras – limited to the VNIR (0.4 to 1.0 µm) spectral range – currently feasible for low-cost missions.

A novel form of imaging spectrometer is presented that represents a considerable advancement over the state of the art in size and performance. A Dyson-type spectrometer design allows high collection aperture (a focal ratio of F/1.8 has been demonstrated) and high spectral resolution, while minimizing spectral artifacts in the data. This spectrometer enables the collection of science data of unprecedented fidelity and enhanced information content, offering both improvements in performance and an order of magnitude reduction in mass. This performance is enabled by JPL's techniques for grating fabrication and for achieving the highest possible response uniformity for the minimization of spectral artifacts, which limit the performance of current imaging spectrometers. The combination of the extremely compact Dyson design with a single, thermoelectrically-cooled detector array reduces the mass of such an instrument by a factor of at least 15, while maintaining the spatial and spectral resolutions of current state-of-the-art imaging spectrometers carried by orbiters and terrestrial aircraft. The utility of this design has been proven by measuring in the laboratory the performance of a breadboard spectrometer module.

Table 1 compares the capability and mass for our Miniature Imaging Spectrometer (MIS) with the capabilities and masses of current state-of-the-art imaging spectrometers: JPL's *Airborne Visible and Infrared Imaging Spectrometer* (AVIRIS); the European Space Agency's *Observatoire pour la Minéralogie, l'Eau, les Glaces*, et l'Activité (OMEGA) instrument on Mars Express; the Applied Physics Laboratory's *Compact Reconnaissance Imaging Spectrometer for Mars* (CRISM) for the Mars Reconnaissance Orbiter; and JPL's *Moon Mineralogy Mapper* (M^3) developed for India's Chandrayaan-1 lunar orbiter.

	AVIRIS	Omega	CRISM	M^3	MIS
Mission	civil aircraft	Mars Express	MRO	Chandrayaan-1	future low-cost
Optical Design	whiskbroom	Offner	Offner	Offner	Dyson
FPA Cooling	mechanical	mechanical	mechanical	passive	thermoelectric
Spatial Samples	677	128	480	600	640
Spectral Resolution	10 nm	13.5 nm	6.6 nm	10 nm	5.9 nm
Spectral Range	0.36 - 2.5 µm	0.35 - 5.1 µm	0.38 - 3.96 µm	0.43 – 3.00 µm	0.4 - 1.7 µm
Mass	**300 kg**	**29 kg**	**33 kg**	**8 kg**	**3 kg**